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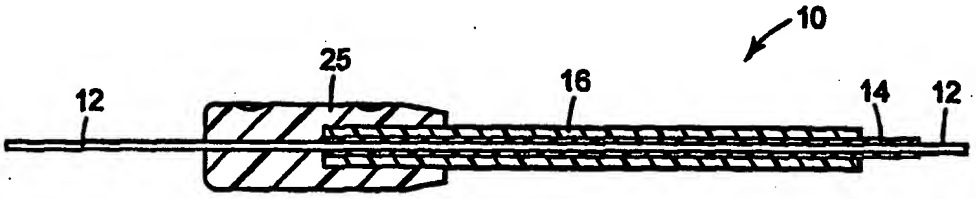
(54) Title: OPTICAL FIBER RETENTION AND STRAIN RELIEF COLLAR



(57) Abstract

A unitary retention piece or collar (20, 25, 32) is provided for mounting and retaining an optical fiber (10, 30) in an optoelectronic device (40). The collar (20, 25, 32) is cast or molded onto an optical fiber (10, 30) to provide a means for mounting the fiber (10, 30), typically on a semiconductor substrate, for alignment with other devices such as laser diodes and photodetectors. The collar (20, 25, 32) can be cast or molded onto the glass fiber (12) with coating (14) and buffer (16) layers in place, or a portion of the buffer layer (16) can be stripped off so that the molded collar (20, 25, 32) extends over both the buffered fiber and a portion of the stripped glass fiber (12). The collar (20, 25, 32) can be molded in any desired external shape for mating with a clip, retainer, socket, or housing to secure the fiber to the substrate or optoelectronic device package (40).

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Optical Fiber Retention and Strain Relief Collar

Technical Field

The present invention relates to optical fibers and, in particular, to an optical fiber strain relief and retention piece that is molded onto the fiber for mating with a connection element of an optoelectronic device.

Background of the Invention

In optical fiber systems, as found in the telecommunications industry, for example, optical fibers must be precisely aligned and secured by some means to function properly with associated devices, such as laser diode light sources and photodetectors. Conventional fiber optic systems typically include multiple part optical coupling elements that tend to be relatively large, complicated, and expensive to manufacture using different and separate processes. In optoelectronic device packages, for example, optical fiber couplings may include epoxy adhered fiber ends within ceramic furrules that mate with stainless steel couplings soldered to metal housings that contain light sources and detectors.

Common coupling elements, such as ceramic ferrules, generally retain stripped optical fibers within inner diameters that are formed to precise tolerances, which are costly to fabricate. Moreover, many coupling elements experience relatively weak bonding between the buffer coated fibers and the metallic sleeves, and/or between the inner ceramic ferrules and the outer metallic sleeves. Furthermore, temperature changes in the environment can cause difficulties for multiple part connectors because of the different coefficients of thermal expansion of the different materials (such as glass, metal, ceramic, adhesives, and polymer coatings) that form or retain the various parts.

Traditional optical couplers, when not used with separate strain relief devices, can allow stresses to exist between the glass fiber and the retaining ceramic or plastic device. Unfortunately, stresses can cause changes in the refractive index of the optical fiber, which can affect optical transfer modes and cause optical transmission loss. What is needed, therefore, is a small, simple, low cost optical fiber strain relief and retention piece that can be adapted to a variety of optoelectronic devices and packages to reduce complexity and provide quality optical transmission.

Summary of the Invention

The present invention comprises a small, unitary piece or collar for mounting and retaining an optical fiber in an optoelectronic device. Optical fibers typically comprise an optical glass fiber (which may include a single mode or multi-mode optical core surrounded by a cladding layer) with one or more coating and buffer layers for a total standard diameter of 125, 250, or 900 microns, for example. The unitary retaining piece and strain relief collar of the present invention is cast or molded onto an optical fiber to provide a means for mounting the fiber, typically on a semiconductor substrate, for alignment with a laser diode light source and/or a photodiode light detector, for example. The collar can be cast or molded onto the glass fiber with coating and buffer layers in place, or a portion of the buffer layer, for example, can be stripped off so that the collar is formed at the junction to extend over both a segment of the buffered fiber and a segment of the stripped (bare) glass fiber. The collar can be cast or molded in any desired external shape for mating with a clip, retainer, socket, or housing to secure the fiber to a substrate or optoelecronic device package.

The use of a single material to provide a fiber retention piece and strain relief collar reduces the problem of stresses caused by the different coefficients of thermal expansion of dissimilar materials. The retention piece may be cast or molded using a polymer material or epoxy resin that can provide relative high pull-out (tensile) strength with a piece having a length of about 10 mm or less. In addition, the cast or molded material can be chosen to withstand the high temperatures (at least 200°C) associated with wave soldering of optoelectronic packages mounted on printed circuit boards.

The unitary, overmolded optical fiber retention piece and strain relief collar of the present invention has many advantages over known alternatives. For example, the overmolded collar eliminates expensive, precision formed ceramic or molded ferrules; does not require adhesives for assembly; eliminates multiple components for the functions of strain relief and precise fiber retention; and does not require the fiber cable buffer layers to be stripped before insertion or assembly into an alignment and retention piece. These advantages combine to provide reduced size and lower costs for optoelectronic modules and cable assemblies.

A principal object of the invention is to provide a means for mounting, positioning, retaining, and securing an optical fiber in an optoelectronic device. A feature of the invention is a unitary strain relief collar and retention piece that is cast or molded onto an optical fiber. An advantage of the invention is a simplified and reduced size retention piece for positioning and securing optical fibers in a variety of optoelectronic devices.

Brief Description of the Drawings

For a more complete understanding of the present invention and for further advantages thereof, the following Detailed Description of the Preferred Embodiments makes reference to the accompanying Drawings, wherein the same reference numerals indicate the same or similar elements throughout the various Figures, in which:

FIGURE 1A is a top plan view of an embodiment of the unitary optical fiber retention and strain relief collar of the present invention molded over a buffer coated optical fiber;

FIGURE 1B is a longitudinal cross section of the embodiment of Figure 1A;

FIGURE 2A is a top plan view of an embodiment of the optical fiber retention and strain relief collar of the present invention molded over a junction of a segment of the buffered fiber and a section of the glass fiber with the buffer layer stripped away;

FIGURE 2B is a longitudinal cross section of the embodiment of Figure 2A;

FIGURE 3A is a longitudinal cross-sectional view of an alternative embodiment of the optical fiber retention and strain relief piece of the present invention;

FIGURE 3B is a top plan view of the embodiment of Figure 3A showing ears or tabs formed on the retention piece;

FIGURE 3C is a side view of the embodiment of Figure 3B;

FIGURE 4A is a top view of the embodiment of Figure 3B mated with an optoelectronic device; and

FIGURE 4B is a longitudinal cross-sectional view of the optoelectronic device of Figure 4A.

Detailed Description of the Preferred Embodiments

Referring to the Figures, a buffer coated optical fiber cable 10 may include a single-mode or multi-mode glass fiber 12, a coating 14, and a protective buffer layer 16. Buffered fiber cable 10 may have any specified diameter, including the standard total diameters of 250 or 900 microns around a 125 micron diameter fiber 12, for example.

Figures 1A and 1B illustrate a basic embodiment of a unitary optical fiber strain relief and retention piece or collar 20 of the present invention. In this embodiment, collar 20 is cast or molded onto buffer layer 16 of a 900 micron diameter optical fiber cable 10. Collar 20

may be cast or molded onto buffered cable 10 in any desired geometry, which may include optional detents 22, without breaking or damaging optical glass fiber 12, for the purpose of facilitating the handling, positioning, retaining, and securing of optical fiber 12 in an optoelectronic device.

In the preferred embodiment, collar 20 comprises a thermoplastic polymer material that can be injection molded onto or around buffered fiber cable 10. Preferred materials include block co-polymers comprising a crystalline (hard) segment of polybutylene terephthalate (PBT) and an amorphous (soft) segment based on long chain polyether glycols (such as selected high performance grades of "Hytrel," a trademark of Du Pont). Alternatively, collar 20 may comprise a material, such as an epoxy resin, for example, that may be cast in a mold. By selecting suitable materials and molding conditions, collar 20 can be formed to withstand high temperatures (up to at least 220°C, for example) and relatively high tensile pull out forces (above 2 Kg., for example) with a relatively small length (typically 10 millimeters or less, for example) collar 20 molded onto buffered fiber cable 10. During the molding process, buffered cable 10 can be positioned and held securely to achieve straightness of fiber 12 protrusion (e.g., consistently within 1° of specification) and to perform secondary operations such as fiber 12 end preparation, including straight cleaving, angle cleaving, and fiber angle orientation, for example. In addition, the length of fiber protrusion from collar 20 can be set and controlled to precise tolerances, and the specific geometry (including the presence of detents, ears, tabs, knobs, notches, etc.), markings, and color of collar 20 can be incorporated for piece identification, orientation, and informational purposes. After collar 20 has been formed around buffered fiber cable 10, buffer layer 16 may be stripped away and the end face of optical fiber 12 may be prepared as necessary for the specific end use desired. The overmolding process and subsequent optical fiber and component assembly operations provide a convenient and consistent part geometry, which allows automated assembly equipment to manipulate and position optical fibers 12 repetitively with precision and high manufacturing yield.

Referring to Figures 2A and 2B, an optical fiber retention piece and strain relief collar 25 is molded onto an optical fiber 12 and buffer layer 16 of 900 micron cable 10. In this embodiment, a segment of buffer layer 16 is stripped away from fiber 12, and then collar 25 is cast or molded onto or around both stripped fiber 12 and buffer layer 16 at the junction (or transition) of the buffer layer 16 with the stripped fiber 12. Collar 25 retains all the advantages described above in conjunction with collar 20, plus the benefit of providing a cleanly stripped section of optical fiber 12 extending from one end of collar 25.

As an example of an alternative geometry, a unitary optical fiber retention piece and strain relief collar 32 is cast or molded onto a 250 micron buffered fiber 30 as illustrated in the

longitudinal cross-sectional view of Figure 3A, the top view of Figure 3B, and the side view of Figure 3C. Collar 32 may include any or all of the features described above with respect to collars 20 and 25. The geometry of molded collar 32 includes ears or tabs 34 as best shown in Figure 3B. Ears or tabs 34 may facilitate securing collar 32 and fiber 30 in a mating clip, socket, or panel (see Figures 4A and B) attached to a substrate or housing of an optoelectronic device. Collar 32 may include detents or marks to facilitate securing collar 32 or identifying a particular side of collar 32 for proper orientation in a socket or supporting mount, for example.

Figures 4A and B illustrate the mating of collar 32 and fiber 30 with an optoelectronic device 40. Device 40 may include a top section 42 and a bottom section 44 with recesses for retaining collar 32 and fiber 30. Device 40 would typically include a laser diode light source or a photodiode light detector for sending or receiving optical signals. Device 40 may also include electrical contacts (or legs) 46 that may be bent for positioning and soldering device 40 to a circuit board, for example. The small size of collar 32 (typically 10 millimeters or less) is particularly important for use on electronic circuit boards where conservation of space is always necessary. Also, the ability of collar 32 to withstand the high temperatures associated with wave soldering of a circuit board with device 40, collar 32, and fiber 30 mounted in place is important for some applications.

The unitary optical fiber retention piece and strain relief collar of the present invention has many advantages over known fiber retention devices. The collar may be formed in a variety of shapes, including those that completely or only partially surround the fiber, for use in a variety of applications. The collar can provide high pull-out strength (over 2 Kg, for example) with a small size and short length (about 6 mm, for example). Additional bonding strength can be achieved by matching the collar material with the fiber buffer material. Strain relief properties, which are important for protecting the optical fiber from breakage at points where stresses concentrate, are provided by the soft (amorphous) material chosen for the copolymer. The collar is well suited for optoelectronic packages that are ultimately sealed from the elements, but from which an optical fiber protrudes. Molding the collar onto the fiber enables very straight fiber length protrusion for placement in fiber alignment features, such as in passive connectors or v-grooves in silicon substrates. Bare fiber lengths of over one inch have been successfully overmolded with a collar without fiber breakage. The collar facilitates handling of the fiber for processing steps such as precision fiber length cleaving, angle cleaving, and subsequent fiber end polishing. The optical fiber may have an end face flush with the collar, may protrude from the collar at one or both ends, and may include buffer layers at both ends or a buffer layer at one end and bare fiber at the other end. The collar can be formed in almost any desired

shape and may include ears, tabs, notches, detents, and marks to facilitate orientation, positioning, retention, and identification of the collar and fiber. The small size of the collar and its ability to withstand relatively high temperatures make it well suited for use in optoelectronic devices that are subsequently soldered to electronic circuit boards.

In addition to the foregoing, the unitary fiber collar of the present invention eliminates the need for expensive, precision formed ceramic or molded ferrules; it does not require secondary assembly operations such as the use of epoxy adhesives; it eliminates the need for multiple components to perform the functions of strain relief and precise fiber retention; it does not require the fiber cable buffer layers to be stripped before insertion or assembly of the optical fiber into an alignment and retention piece; and it may be molded around multiple fibers to form a multi-fiber strain relief and retention unit. These advantages combine to provide a unitary optical fiber retention piece and strain relief collar having reduced size and lower costs for use in a variety of optoelectronic modules and fiber optic cable assemblies.

Claims:

1. An optical fiber assembly comprising an optical fiber (10, 30) and a fiber retention piece (20, 25, 32), characterized in that:

said fiber retention piece (20, 25, 32) comprises a unitary piece molded onto said optical fiber (10, 30); and

said unitary retention piece (20, 25, 32) provides fiber strain relief and comprises a means for retaining said optical fiber (10, 30) in an optoelectronic device (40).

2. The assembly of Claim 1, further characterized in that said optical fiber (10, 30) includes an outer buffer layer (16) and said unitary fiber retention piece (20, 25, 32) is molded onto said outer buffer layer (16) of said fiber (10, 30).

3. The assembly of Claim 2, further characterized in that said unitary fiber retention piece (20, 25, 32) comprises a thermoplastic polymer material molded around said outer buffer layer (16) of said fiber (10, 30).

4. The assembly of Claim 1, further characterized in that said optical fiber (10, 30) includes a junction of a first segment with an outer buffer layer (16) and a second segment (12) stripped of said buffer layer (16), and wherein said unitary fiber retention piece (20, 25, 32) is molded onto both said buffer layer (16) and said stripped segment (12) at said junction.

5. The assembly of Claim 1, further characterized in that said unitary fiber retention piece (20, 25, 32) comprises a polymer material able to retain said fiber (10, 30) and provide strain relief at temperatures up to about 220°C.

6. The assembly of Claim 1, further characterized in that said unitary fiber retention piece (20, 25, 32) is formed from a co-polymer material comprising a crystalline segment and an amorphous segment based on long chain polyether glycols.

7. The assembly of Claim 6, further characterized in that said crystalline segment of said co-polymer material comprises polybutylene terephthalate (PBT).

8. The assembly of Claim 1, further characterized in that said unitary fiber retention piece (20, 25, 32) includes means (34) for mating said retention piece with said optoelectronic device (40).

9. The assembly of Claim 8, further characterized in that said retention piece positioning means (34) are selected from the group consisting of ears, tabs, notches, detents, and marks.

10. The assembly of Claim 1, further characterized in that said unitary fiber retention piece (20, 25, 32) has a length no greater than about 10 millimeters and a fiber pull-out strength of at least 2 Kg.

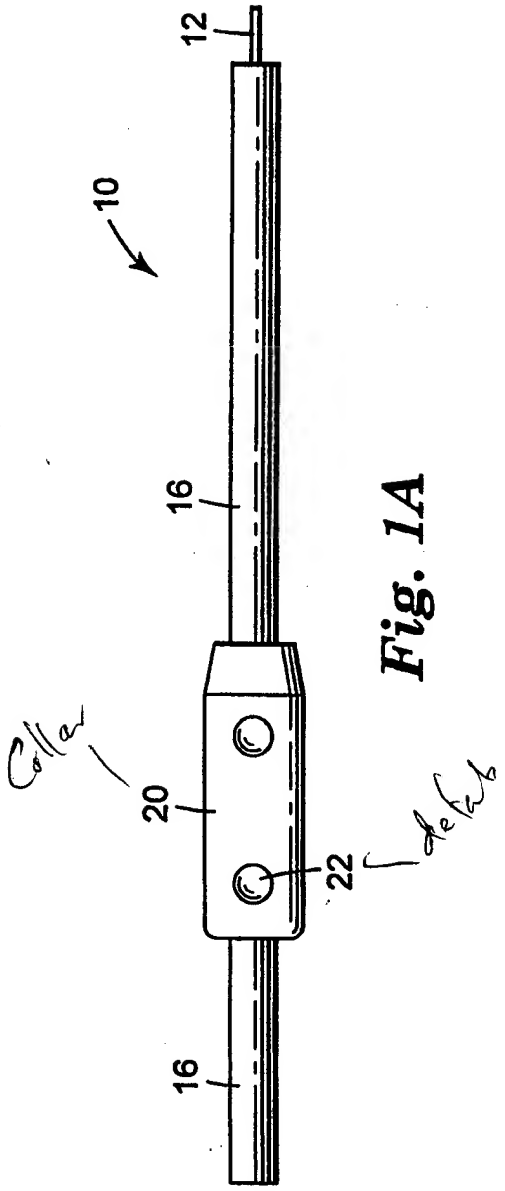

Fig. 1A

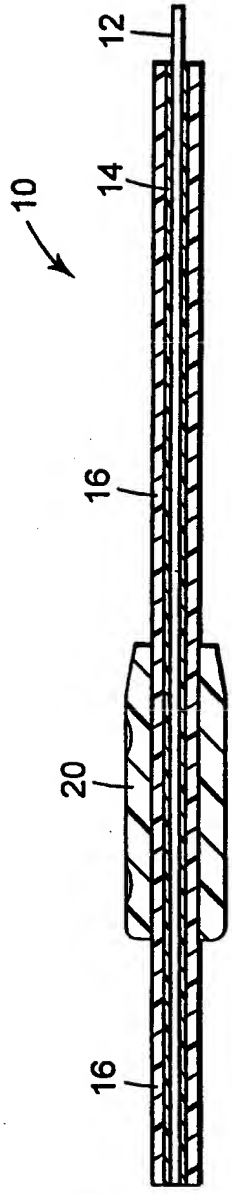

Fig. 1B

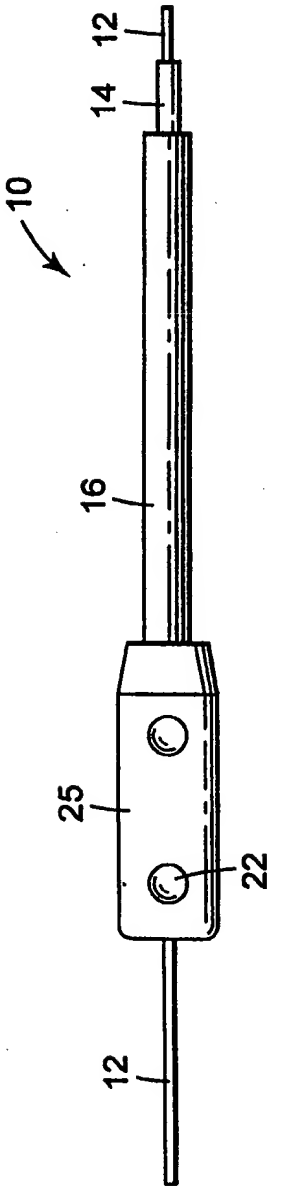

Fig. 2A

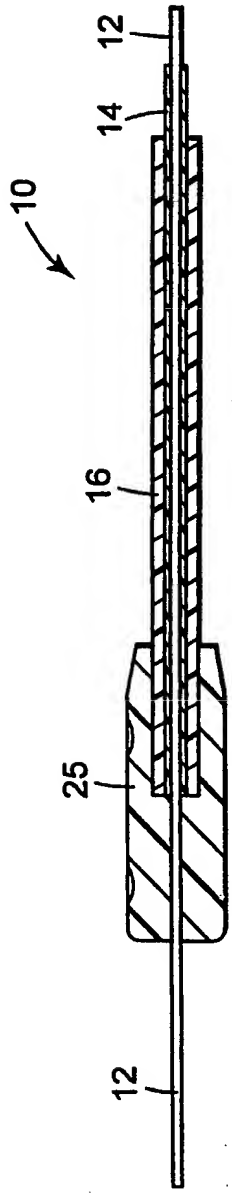

Fig. 2B

Fig. 3A

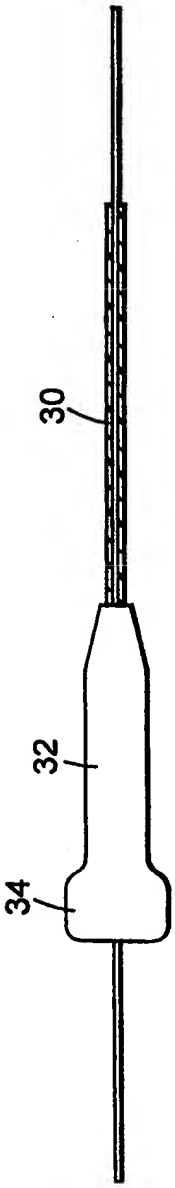

Fig. 3B

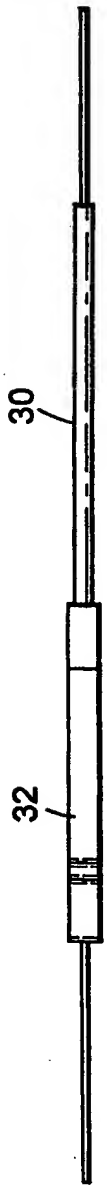

Fig. 3C

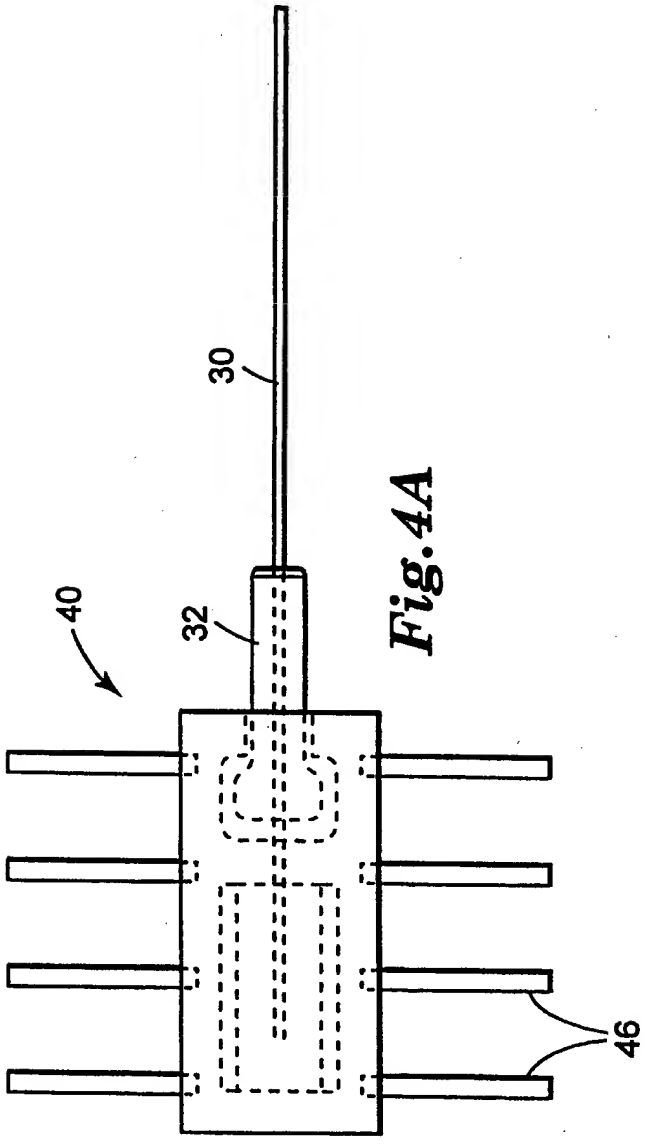

Fig. 4A

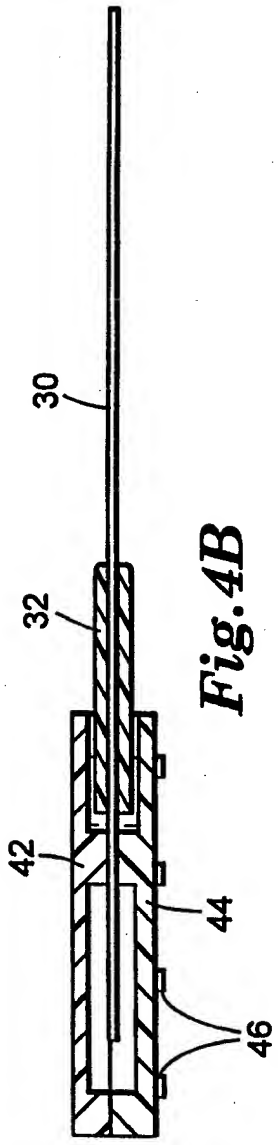

Fig. 4B

INTERNATIONAL SEARCH REPORT

Interna al Application No
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A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G02B6/38 G02B6/42

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
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C. DOCUMENTS CONSIDERED TO BE RELEVANT

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X	WO 92 19997 A (BURNDY DEUTSCHLAND) 12 November 1992 see page 7, line 12 - line 27 see page 8 - page 9 see figures	1-3,8
X	DE 39 02 836 A (TOKAI RUBBER IND LTD) 31 August 1989 see column 6, line 21 - line 68 see column 7, line 1 - line 21 see column 12, line 49 - line 65 see column 13, line 1 - line 36 see figures 1,2,6-8	1-3
A	idem	7

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